The women day storm

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Abstract

On behalf of the International Women Day, the Sun gave a hot kiss to our mother Earth in a form of a full halo CME generated by the yesterday's double X-class flare. The resulting geomagnetic storm gives a good opportunity to compare the performance of space weather forecast models operating in near-real-time. We compare the forecasts of most major models and identify some common problems. We also present the results of our own near-real-time forecast models.

1 Introduction

The storm started yesterday with a side blow from a CME generated by the X1.1 flare on March 5th after a long period of southward-directed IMF. This first G2 storm scored the K_P index of 6 and lasted over 12 hours. Around midnight on March 7th a huge X5.4 flare has spewed an Earth-directed CME, almost immediately causing an R3 blackout and an S3 radiation storm. It was soon followed by an X1.3 flare, but whether this one was followed by a CME is not clear. This is a very important issue, since all known superstorms were caused by several sequential CMEs. According to SOHO measurements at about 1000Z the solar wind velocity rapidly increased from 500 to 700 $\mathrm{km\,s^{-1}}$ with a peak value of 800 $\mathrm{km\,s^{-1}}$. Today at 1105Z the CME has hit the Earth causing an impressive 58nT sudden impulse and instantly pumping K_P to 5. The B_Z component was northward most of the time. For this reason, this

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storm is much weaker than it could be. If the IMF turns southward for a considerable length of time, it will become much more intense.

To add to forecasters' troubles, the ACE data was unavailable for most part of the day. Since the availability of near-real-time (NRT) solar wind data is critical for most space weather (SWx) forecasts, it is intriguing to see how the forecast models perform in such conditions. We will consider only the forecasts of the geomagnetical indices D_{ST} and K_P, since these are the most widely used SWx parameters.

2 Analysis of the models' performance

We start with the D_{ST} index, since it was historically the first proxy for SWx forecasting. The NRT online models include the empirical Temerin and Li model (http://lasp.colorado.edu/space_weather/dsttemerin/dsttemerin.html), and two models based on artificial neural networks: the Wintoft Dst model (http://rwc.lund.irf.se/rwc/dst/index.php) dating back to 2002 and the NICT model (http://www2.nict.go.jp/aeri/swe/swx/ace/nnw/) . All these models provide 1 hour lead time, so they are nowcast rather then forecast models. Recently they were joined by a new empirical model by Podladchikova (http://www.spaceweather.ru/content/extended-geomagnetic-storm-forecast), which outputs not the D_{ST} index itself, but an estimation of its peak value. For this reason, the lead time cannot be clearly defined for this model, but typically the storm is forecasted 2-3 hours before the commencement. Also, there is a model developed by the authors of this article, which will be integrated in the DLR's Space Weather Application Center Ionosphere (http://swaciweb.dlr.de/). It uses the regression modelling approach and provides 3 hours lead time.

Let us see how these models performed during this storm. Temerin and Li model overestimated the magnitude of the first storm by 50%, and Wintoft Dst model totally missed the sudden impulse, but otherwise they provided a reasonable forecast. The NICT model overestimated the first storm's magnitude by 25% and missed the sudden impulse. Podladchikova model overestimated the magnitude of the first storm by 25%, and her peak value prediction approach does not give the information on the onset time. Our D_{ST} model delayed with the storm onset prediction and missed the sudden impulse. Also it sometimes lags 1-2 hours behind the Kyoto D_{ST} (thus providing 1-2 hours lead time).

Next we switch to the K_P index, which gained some popularity lately due to its apparent clarity. Unfortunately, the harsh reality is that the K_P index is notoriously difficult to use both for research and operational purposes due

to the lack of physical sense.

The state-of-the-art Wing model (http://www.swpc.noaa.gov/wingkp/) became inoperational since 0830Z yesterday and still shows no vital signs. Wintoft Kp model (http://rwc.lund.irf.se/rwc/kp/index.php) stopped working about yesterday noon occasionally providing unrealistically low K_P forecasts (less then 1 K_P unit). Our K_P model underestimated the storm intensity by almost 3 times but at least it worked through the whole event.

3 Conclusion

All operational K_P forecast models failed during the storm. The D_{ST} forecast models appeared to be less affected by the lack of NRT data and provided better accuracy. Considering the more evident physical meaning of the D_{ST} index, it seems reasonable to use it for global models, and to develop regional indices for specific areas, especially in high latitudes.

The problem of missing ACE data can be addressed by filling the gaps in data. Such software is currently being developed by the authors of this article. Hopefully, future spacecraft for solar wind monitoring will have some sort of radiation-resistant instruments providing at least some very rough NRT data. In situations like this one it is better to have very rough data on the solar wind velocity than to have no information at all.
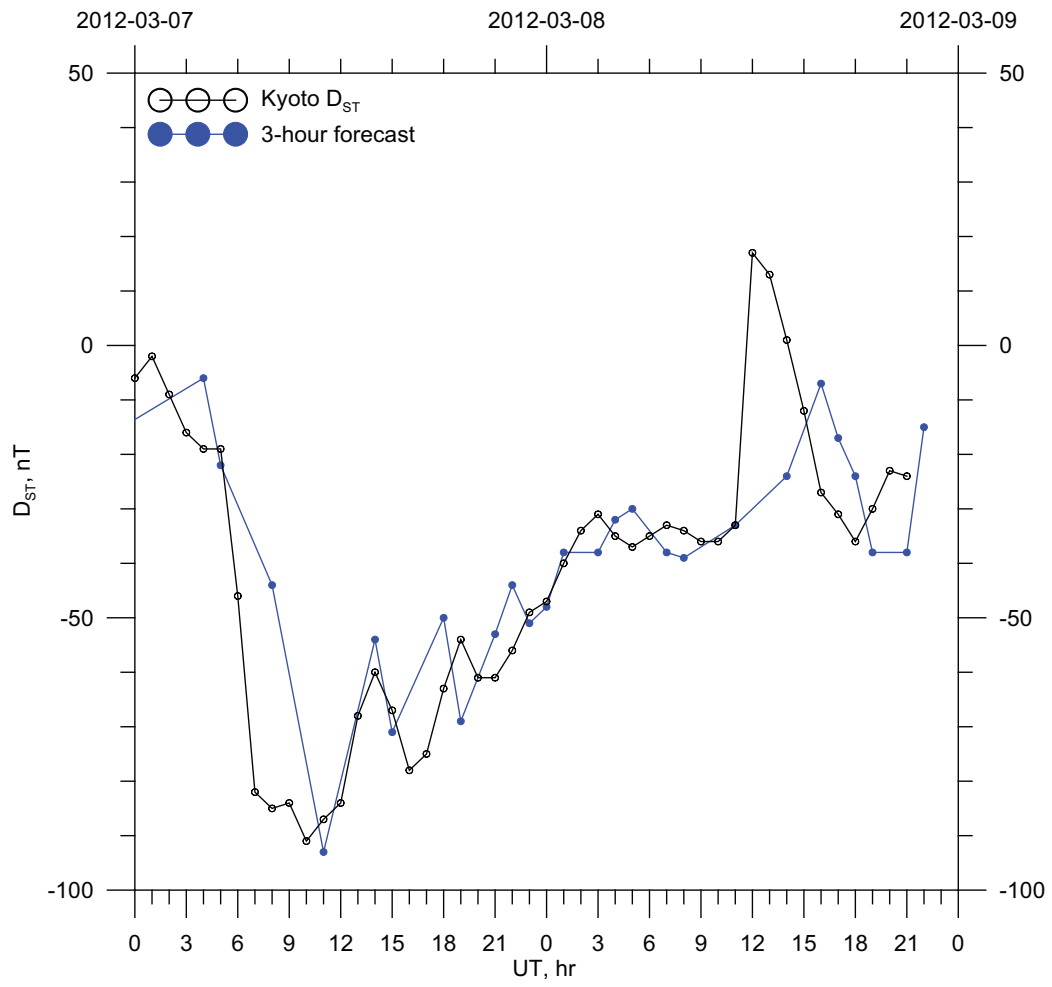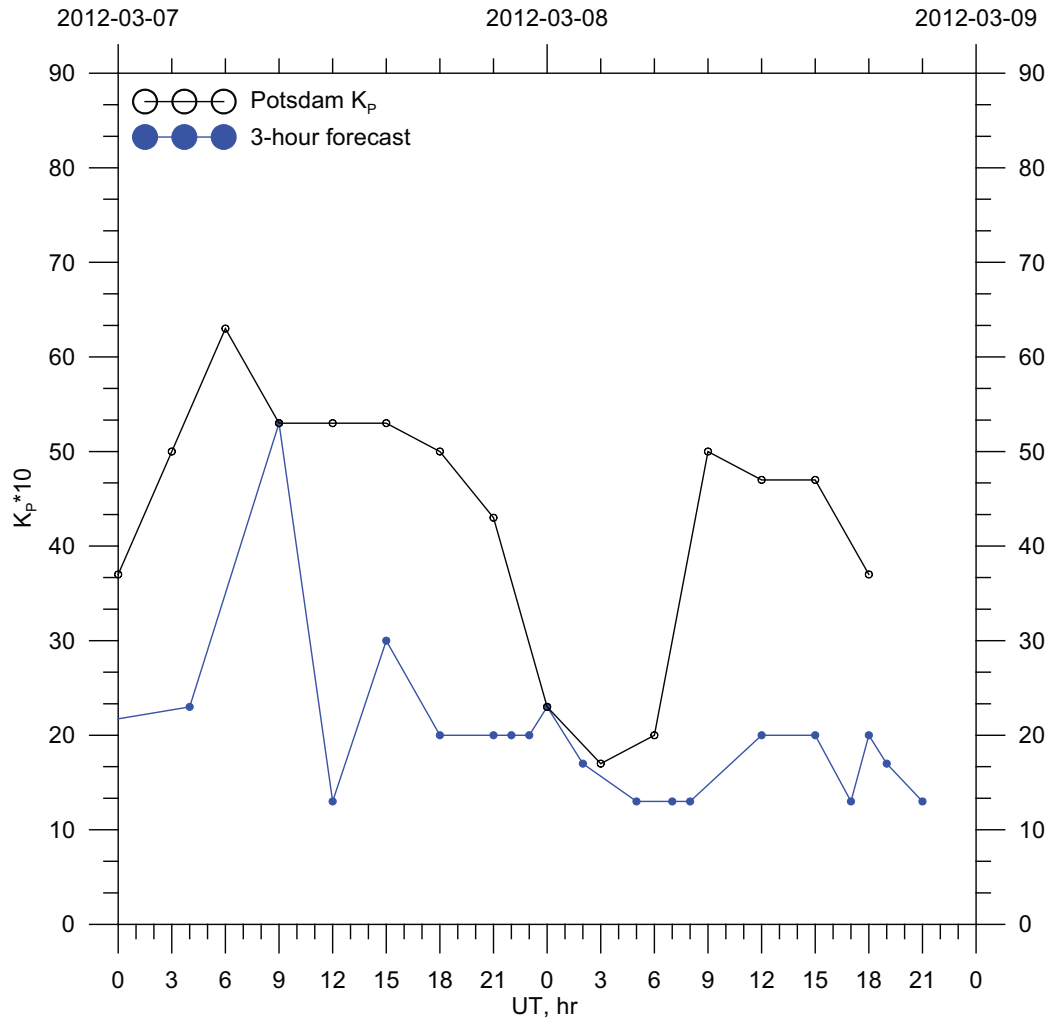
4 Acknowledgements

Figure 1: Our D_{ST} model

Figure 2: Our K_P model